2000 CALFED Science Conference
Session Notes

Levee System Integrity

Session Chair: Lauren Hastings
Session Notetaker: Gwen Knittweis

Stability of Delta Levees – R. Kevin Tillis, Hultgren-Tillis Engineers.

Kevin Tillis discussed the nature of Delta levees, factors of concern for slope stability, and methods to improve slope stability, with a focus on Delta levees unlain by peat. Tillis reviewed a brief history on the reclamation of Delta Islands that has led to present day levee conditions. A typical Delta levee is different from levees in other geographical areas as it may impound water year round with a 0-3 foot tidal fluctuation. A typical waterside slope is 2:1 and landside slopes are from 3:1 to 5:1. Levee materials typically include fill (from 5-15' mineral soil) over peat over sand. Factors to be considered for slope stability include levee material, geometry, and water pressure. In discussing ways to increase levee stability, Tillis focussed on geometry and strength of materials since water pressure is not as variable. He noted that, although settlement may cause loss of levee freeboard, placing material high on levee underlain by peat is not preferred for stability. He suggested using a toe berm in this case to improve the factor of safety. Peat is a weak and compressible material. Placing fill on peat at the toe of the levee increases the effective stress and will eventually strengthen peat. Key summary points included: Don't place material high on levee, use toe berms, expect significant settlement and deformation, construct to fill thickness not elevation because peat can be stressed to failure (must look at masses to assure adequate safety), and monitor closely during construction.

Seismic Vulnerability of the Sacramento-San Joaquin Delta Levees – Leslie Harder, DWR.

Leslie Harder presented a summary of seismic risk analysis and assessments performed by the Seismic Vulnerability Sub-Team. Over 600 miles of levees were considered in the assessment. Les made a brief review of the history of Delta levee construction and subsidence that has led to levees that are typically 20-25'. He noted that vulnerability is a function of seismicity and fragility. In reviewing seismicity, two models were considered: one model including a "hidden" CRCV fault that many theorize exists and another, the Lettis model, which theorizes no CRCV fault. Contours of acceleration were figured for a 100-yeat return period and varied from 20% - 10% gravity from the West to East Delta. The Delta area was divided into 4 zones of seismicity. In reviewing levee fragility, a "levee breach" was defined as a complete breach of the levee system leading to flooding of an island. Factors of failure included soil liquefaction and inertial/dynamic deformation. Fragility was expressed as the number of levee

failures for each of the different seismic zones. For illustration, Les showed that for the CVCR model with a magnitude 6 event, up to 20 levee failures are predicted. The median number of failures for a hundred year event was 5-6. Les stated that no historical earthquake damage has ever been recorded in the Delta. The highest recorded shaking to date is up to .08 g in the West and 0.05 g in the East Delta. There was discussion as to whether it would be possible to upgrade levees to withstand the worst earthquake. Les commented that the cost would be prohibitive and one would never be assured 100% that no failure would occur.

Levee Stability Impacts From Seepage Induced by Delta Island Flooding – Edwin Hultgren, Hultgren-Tillis Engineers.

Edwin Hultgren discussed seepage impacts to levee stability and methods to control seepage. He focussed on seepage in the deep aquifer under levees. He explained that he had performed a 2-D mathematical analysis of varying seepage conditions. Conditions examined included a typical case, a case with slough flooding, a case when a neighbor island was breached, and a case with channel dredging. He compared head loss for each case. The head at the toe of the interior levee slope was measured to be –16 for the existing case, -14 for the flood sage (2 ft head loss), -12 for the neighbor island flooding (4 ft loss) and –10 for the dredging slough (6 ft loss). The installation of a relief well allowed excess head to seep into the ditch. Stability analysis for the cases showed that failure circles were nearly the same except for when pressures were very high. The additional of a relief well and adding a 7:1 slope and a 10:1 slope toe berm were examined for their effects on the stability. All were effective in decreasing head loss, with the 10:1 toe berm being the most effective. It was concluded that water pressure influences stability and that ways to help should be examined such as relief wells and toes berms. There was discussion of what landside boundary conditions were used in modeling. In the modeling, they used a large evapotranspiration number and allowed for flow if the head was higher than he ground surface.

Subsidence as Related to Water-Supply Vulnerability in the Sacramento-San Joaquin Delta, California – Steven Deverel, HydroFocus, Inc.

Steve Deverel discussed the importance of subsidence and the need to reverse it and its effects. He stressed that increased subsidence increases the volume of water inundating an island in a flood. To illustrate impacts of island flooding he noted that Brannon Andrus resulted in 150,000 AF flooded, 50,000 tons of extra salt exported, $20 million spent, and the SWP being shut down for 1 month. Deverel reviewed the causes of subsidence including consolidation, burning, wind and oxidation. He stated that oxidation becomes the predominant cause of subsidence over time and showed subsidence data from Mildred and Sherman Islands that supported his point. He noted that a key issue is carbon mass balance and that permanent wetlands lose much less carbon than agricultural use. Deverel stressed that subsidence reversal is essential for ecosystem

benefits, water quality benefits, water supply benefits, and dredged material use. In order to facilitate subsidence mitigation, better delineation of priority areas is needed. Highest priority areas are where high rates of subsidence meet a high volume of organic soils. Deverel pointed to a need for more information on current subsidence rates, peat thickness, priority area, accretion rates, water quality effects, optimal accretion methods, and long-term effects on levee stability. In summary he stressed the need to the fill data gaps, noted that oxidation is the primary cause of subsidence, and indicated that biomass accretion holds promise. Questions included whether dredged soil is suitable for subsidence reversal to which Deverel noted it would be dealt with on a case-by-case basis. There was a question on the rate of biomass accretion and Deverel replied that 2mm/year is historical although he suggests that there is hope to beat this rate. There was a question as to whether groundwater pumping causes consolidation in the Delta to which Deverel replied that it is not an issue in the Delta.

The Potential for Subsidence Control Through Wetlands Restoration in the Sacramento-San Joaquin Delta – Robin Miller, USGS.

Robin Miller discussed the results of a study performed on Twitchell Island, which involved flooding the Island and planting tules and cattails to show how wetlands affect the Carbon process. Wetland areas were flooded at two different depths to also consider the effect of depth. Measured inputs included biomass harvest, estimates of leaf/stem turnover, and transects to quantify plant coverage. Measured losses included gas fluxes through plants and decomposition through litter decomposition bag studies. Biomass contributors were cattails and tules. Methane emissions were measured showing low emissions for some time with some recent spikes. Decomposition bag studies involved leaving plant litter for several years and drying and weighing to see what is left over time. Studies showed that after 2 years, 5-15% of the material was left. In summary, it was noted that there is a significant drop in CO2 with flooding. Measured carbon losses versus inputs indicate storage. There was no noted difference in productivity between water depths, as deeper water resulted in taller but less dense plants; however, it was noted that depth slows colonization.

Twitchell Island Levee Setback and Habitat Restoration Project – Christopher Nuedeck, KSN Inc.

Chris Neudeck presented the highlights of a project on Twitchell Island that successfully combined levee integrity improvements with habitat creation. The project involved construction of a setback levee on critical section of the San Joaquin River where the river is 2500’ across and waters are 65’ deep. This existing levee section had a steep deep waterside slope and unstable foundation. The project successfully increased the factor of safety from 1 to 1.4 on the waterside and 1.7+ on the landside with a levee setback 140’ and provided for habitat restoration. Phase one in 1991-92 involved developing a toe-berm 120'

wide with material from Clifton Court Forebay that was placed on the backslope of the Twitchell levees. Next the setback levee was constructed in 300' lifts with careful monitoring to make sure that underlying peats were not failed by loading too quickly. In Phase 2 starting in 1999, the remnant levee was used to create habitat, in lieu of flattening out the waterside slope and rocking it as was originally intended. There was initially much skepticism in putting habitat in one of the most critical Delta areas. 3' of rock was placed on the new setback levee and 18" of rock was placed on the remnant levee with 1' of fill overlain that was used to plant trees. The final design will call for 12 openings in the levees to be constructed to allow for flow-through and maximize habitat creation. The conclusion was that the project was a success in increasing the levee integrity and also maximizing habitat creation potential. The project was expensive, however, at $2.5 million/ mile and from $3.5-4 million a mile with planting costs included (total project length was 3000'). There was question as to whether the new habitat sections created from the remnant levee will be stable and it was noted that they will required human intervention to be maintained although the are essentially sacrificial with regards to the levee integrity.

The AB360 Program- A Program of Synergy Between Habitat Creation and Levee Maintenance in the Delta – James Martin, DWR.

Jim Martin presented background the AB360 Program's habitat enhancement requirements and highlighted ongoing projects illustrating the Program's successful implementation. There are currently 19 projects throughout the Delta that are developing habitat or are in planning stages. Restoration opportunities may be presented by levee setbacks, remnant channel islands, new channel islands, peripheral Delta Islands, interior Delta islands and existing levees. DWR's Grizzly Slough Project provided for created wetland habitat by excavating mineral soils (which were used for levee maintenance) and supplying water through a 24" pipe with a gate valve. On Tyler Island, DWR staff worked with Jeff Hart installing ballast buckets with plantings to aid in erosion protection. There were some survival problems with original species used for planting, but a hardier species is surviving well. On Decker Island, 5 acres of diverse wildlife habitat is being created. The project includes excavating to –7 feet, leaving some areas up to +_15 for valley oaks and cottonwoods and installing root wads for biological revetment. Jim stressed that the AB360 program continues to learn and develop new techniques for successful habitat enhancement. Jim mentioned that DWR Central District is currently publishing a summary document to outline the workings of the program in detail.

Cooperative Participation in Delta Levee Habitat Development and Levee Maintenance – Gilbert Cosio, MBK Engineers.

Gil Cosio discussed the need for communication, cooperation, and adaptive management in achieving levee maintenance that allows for habitat enhancement. Gil noted that, contrary to popular perception, some of the most

vegetated areas are riprapped banks. Gil illustrated the challenge facing Delta levees with pictures of Webb Tract levees following high wind and high tides that reduced levees from 20' wide at the crown to 6'-8' wide in some areas. He gave examples of levee maintenance efforts that incorporated habitat enhancement. On Ridge Tract, levee maintenance was achieved using more precise spraying techniques that allowed a band of tules to grow that also serve as a wave break. Gil showed an example of a Delta island borrow pit that was previously connected to an irrigation system and planted with willow clippings and now exists as a well-populated frog pond surrounded by willows. On Canal Ranch, mowing in lieu of spraying was used for maintenance, so levees can still be inspected but less habitat is disrupted. Gil noted that on a project on Canal Ranch in Beaver Slough, erosion problems were solved by repairing the levees in conjunction with building a planter box 1' above the high tide and installing root wads. After only 1-1/2 years, the site is flourishing. Gil also noted the Decker Island project previously discussed in Jim Martin's AB360 Program discussion. Gil noted that Grand Island levees that have rush and tules grown in were a good opportunity because the levee has an enormous structural section leaving 14' of freeboard. There were questions regarding redirected impacts (such as loss of channel capacity) from the Canal Ranch project. Gil explained it was not of issue because in that case as it was a backwater slough. It was asked if a farmer who engineered the frog pond would get mitigation credit for habitat creation and Gil commented that the farmer would have to set up an easement to do so.

Restoration of Delta Floodplain Terraces Through Bioengineering – Jeffrey Hart, Habitat Assessment and Restoration Team, Inc.

There is a great need to develop soft bank protection techniques in the Delta. The Tyler Island embankment on Georgiana Slough is one of the few remaining soft embankments. Jeff Hart presented the results of his efforts at using softbank protection on Georgiana Slough embankments for erosion control. His technique involved using biotech structures and installing plants to retain sediment, reduce re-suspension of sediment, and also create shallow water habitat. Sediment is mainly accumulated in the winter and lost in the summer. Jeff used coir biologs, brush boxes, and ballast buckets to provide damping effects on waves and to capture and retain sediment during the winter. Monitoring was performed for sediment deposition by placement of erosion pins. 4 sites were monitored including 12 scallops of similar dimensions. 1/3 of the sites were control. Monitoring results showed that all sites, including controls, collected sediment in the winter. However, in the summer boating season, almost all sediment was lost on the control sites, but was retained in the biostructure areas. One reason is because the brushworks have a calming effect on the waves. Additional monitoring is also being performed to see if wave energies affect the abundance of macroinvertebrates. In conclusion, it was noted that bioengineering can dampen waves and hold sediment and appears to foster the recruitment of plants and protect aquatic life.

Application of Models for Planning Controlled Levee Breaches in Tidal Wetland Restoration Projects – Christopher Enright, DWR.

Chris Enright presented the results and conclusions from model runs that were performed in coordination with the Suisun Marsh Levee Investigation Team to examine the salinity response to breaching levees in the Suisun Marsh. Chris performed modeling pursuant to the February 1998 floods in Suisun Marsh. He used 1991-1992 drought hydrology for one-dimensional DWRSIM modeling of 2 scenarios for the February breaches. One scenario included 11 breaches (approximating the location of the February breaks) with 100' wide opening and one scenario had 5000' openings simulating "unrepaired breaches" that were left to propagate. Modeling results showed that 100' breaches resulted in lowering salinity in some regions of the Delta, while the "unrepaired" breaches showed salinity increases throughout the system. Additional modeling was performed for the CALFED Suisun Marsh Levee Investigation of tidal marsh and shallow water habitat creation scenarios in order to examine the potential of providing water quality improvements with habitat creation consistent with CALFED's ERP. Results and trends were very similar to the initial modeling for the February floods. Two-dimensional modeling was performed to verify the results. Modeling results revealed two competing mechanisms at work that effect salinity response: 1) Breached areas dissipate tidal energy, causing upstream salinity reduction and 2) asymmetry between tidal flow inside and outside the breach can trap salinity and facilitate mixing, causing upstream salinity increase. Main investigation conclusions included that maintenance of Suisun Marsh levees is important for Delta salinity control, potential opportunities exist for ecosystem restoration and water quality benefits, and salinity response is requires further study and a strong pear review process.